Respiratory Medicine (2000) **94,** 735–741
doi:10.1053/rmed.2000.0814, available online at http://www.idealibrary.com on IDEAL®

Topical Review

Correlation between objective measures of airway calibre and clinical symptoms in asthma: a systematic review of clinical studies

E. Ståhl

Department of Respiratory Medicine, University Hospital, Lund, Sweden

Clinical symptoms are often used as a measure in asthma management, but a variety of symptoms and scales are available. The objectives of this systematic review were as follows:

(a) to present correlations between symptoms and measures of airway calibre; (b) to present the scoring systems/scales used in the publications.

In the review, more than 10 000 publications were found under the key words: asthma and symptom(s). Twenty-one remained when FEV_1/PEF, scale/score and correlation were added as key words.

In summary, no standardized method exists for measuring asthma symptoms with respect to severity. This is the case for both the symptoms and the scales. There are two recently-developed asthma-control scales available (one of which has not yet been published and is not included in the review).

Key words: asthma; symptoms; review; correlation; FEV_1; PEF; scale.

Respir. Med. (2000) **94,** 735–741

Introduction

Asthma is a chronic disease which affects the daily lives of many patients. It is characterized by coughing, wheezing, chest tightness and difficult breathing that are usually reversible. Intermittent exacerbations occur in which the severity of symptoms increases and the response to therapy may be reduced. The goals of asthma therapy are to improve the patient's quality of life by achieving and maintaining control of symptoms, preventing exacerbations, attaining normal lung function and maintaining normal activity levels.

Objective measurements have been, and still are, important in the evaluation of the status of patients with asthma. Measurements of airway function, such as forced expiratory volume in 1 sec (FEV_1) and peak expiratory flow (PEF), were the first parameters to be used for assessing disease severity. Spirometry test and measurements of PEF are recommended to be performed in a standardized way which gives confidence to these measurements. The recommended methods have been developed and published by both European and North American societies. Despite recommendations for performance, calibration of instruments and patient education are still points to consider. However, these measurements have been, and are, invaluable tools for showing that treatment of asthma improves airway function. Still, it has proved a little more difficult to translate such measurements into an understanding of whether or not the improvement is clinically important.

The objective measurements such as FEV_1 and PEF do not always reflect all the disease processes, such as hyperinflation and airway plugging, that occur in asthma. Evidence from clinical studies suggests that lung function measurements do not always follow other markers of disease activity. In a study in mild asthmatic patients treated with budesonide or placebo for 1 year, asthma symptoms improved in steroid-treated patients but not in those receiving placebo. Despite these improvements, there was no change in FEV_1 (1).

Moreover, in patients with mild asthma there are no measurements sensitive enough to evaluate the treatment, even though patients may experience a reduction in airway symptoms.

Clinical symptoms of asthma are often used in clinical studies but not collected in a standardized way. The relationship between the perception of asthma symptoms and lung function measurements in asthmatic patients is poorly understood (2). It is also important to distinguish between asthma severity and asthma control. Asthma severity may be defined as an estimate of the severity of the underlying disease process, whereas asthma control is an estimate of the efficacy of treatment (3). The majority of studies in this review used different symptom scales in order to measure severity. In one publication an asthma control scale was used.

Received October 1999 and accepted in revised form 25 February 2000.

Correspondence should be addressed to: Elisabeth Ståhl, Astra Zeneca R&D Lund, 221 87 Lund, Sweden. Fax: +46-46 33 75 53; E-mail: elisabeth.stahl@astrazeneca.com

0954-6111/00/080735+07 $35·00/0

Over the last 25 years much research has been conducted concerning the development and validation of a questionnaire that would quantify the impact of disease on daily life and well-being from the patient's point of view. In recent years a number of both generic and disease-specific quality of life questionnaires have been developed. Problems have been experienced in producing a questionnaire which is sensitive enough to detect any change, as many patients with mild asthma do not undergo any measurable deterioration in their quality of life, thereby making it impossible to show any improvement (4).

Other possible limitations with questionnaires may be the linguistic validation. Recommendations of how a proper translation, which also includes a cultural adaptation, should be performed are published (3,4). However, these recommendations are focused on quality of life questionnaires, and symptom questionnaires are often not considered as having the same degree of importance.

'Symptom-free days' is an outcome variable recommended in the guidelines for use in economic evaluations of asthma (5). In a publication by P.W. Jones, an attempt was made to identify all possible measurements of disease severity in mild asthma, one of which is symptom-free days (6). However, it is relatively insensitive because no consideration has been given to the severity of symptoms.

OBJECTIVES

This systematic review has the following objectives: (a) to present correlations between symptoms and measures of airway calibre (different scoring systems for symptoms will also be discussed); and (b) to present the scoring systems/scales used in the publications.

Methods

In a literature search in MEDLINE, EMBASE and Current Contents for publications dating from 1966 to March 1998, 10 221 references were found under the key words asthma and symptom(s). The most commonly mentioned symptoms were wheeze and cough, followed by dyspnoea. The figures below show the number found in each of the databases.

In a review covering all publication years, wheeze was mentioned in 1534 papers in MEDLINE, 602 in EMBASE and 251 in Current Contents. Cough was found in 1492 articles in MEDLINE, 678 articles in EMBASE and 195 in Current Contents. For dyspnoea the figures were 1060 in MEDLINE, 411 in EMBASE and 99 in Current Contents. Other frequently mentioned symptoms were sputum, shortness of breath, chest tightness and phlegm. In this review, no consideration has been given to the frequency or duration of the symptoms. Publications dealing with Quality of Life questionnaires including symptoms have been excluded from the present review.

In this review, the key words 'asthma' and 'symptom' have been combined. Additional key words are: forced expiratory volume in 1 sec (or FEV_1); peak expiratory flow (or PEF); score or scale and correlate.

Twenty-one publications were found. In the section below, the papers that included correlations between symptom scales and FEV_1/PEF will be presented, and the different scales and scores will be discussed.

Results

CORRELATIONS

In 20 of the 21 publications, a test for correlation between symptoms and FEV_1/PEF was performed. The remaining paper was a review article. Details of all studies are presented in Tables 1 and 2. In 15 studies there was little or no correlation between symptoms and spirometry tests, but in the remaining five studies statistically significant correlations were found between the subjective and objective measurements. However, in a few studies the correlation values were mixed, i.e. statistically significant correlations were found in a number of comparisons, whilst the remaining correlations were not statistically significant. Eight studies were performed in children and/or adolescents with asthma, and the other 13 in adult asthmatic patients.

In the following five studies (nos. 3, 14, 15, 18 and 19 in Tables 1 and 2) a statistically significant correlation was found between airway calibre and symptoms.

In one paper, number 3 by Blanc *et al.*, published in 1993, the severity of asthma score based on clinical variables was shown to correlate with work disability, $r = -0{\cdot}6$, $P < 0{\cdot}001$ (7). However, this study had only one question on respiratory symptoms. The remaining questions concerned steroids and rescue medication etc., a total of 12 additional questions with yes/no answers.

In the second study (No. 14 in Tables 1 and 2), performed by Morris *et al.* and published in 1996, the severity module from the Monash Respiratory Questionnaire was used (8). This questionnaire was developed by one of the authors and includes frequency of wheezing, nocturnal attacks, asthma attacks, nocturnal wheeze, exercise-induced asthma and dyspnoea. In addition, there are questions on history of emergency room visits, hospitalizations and use of oral steroids. The asthma severity scores correlated with use of rescue medication and daily dose of inhaled steroids, but not with FEV_1 or forced vital capacity (FVC). The severity module of the Monash Respiratory Questionnaire was shown to be a valid and reliable instrument for measurement of the severity of asthma.

The third of these studies (No. 15 in Tables 1 and 2) was published in 1985 by Pauli *et al.* and shows an individual correlation between objective and subjective measurements (9). There were four parameters in the symptom scoring, night-time and daytime dyspnoea, breathlessness and cough. The scores ranged from 0 (no symptoms) to 3 (maximum symptom score). The authors found a global correlation between symptoms and PEF that was statistically significant in 10 out of 13 patients ($P = 0{\cdot}01$ in eight cases and $P = 0{\cdot}05$ in two cases). When use of medication (bronchodilators and corticosteroids) was compared with symptoms, the correlation was statistically significant in only eight of the 13 patients. However, incomplete diary cards revealed

TABLE 1. Characteristics of patients and design from publications

	Author (publ. year)	No. of patients	Age range mean or (years)	Study design	Study duration
1	Apter A.J. (1994)	13	mean 43.5	PEF, symptoms at home	9 weeks
2	Bailey W.C. (1992)	199	15% < 30 years, 10% > 70 years	FEV_1	1 day
3	Blanc P.D. *et al.* (1993)	56	18–55	FEV_1	1 day + 1 day 2 yrs later
4	Boulet L.P. (1991)	26	mean 43.2	PEF, symptoms at home	4 weeks (after acute exacerbation)
5	Carswell F. *et al.* (1990)	86	5–15 (mean 11.2)	PEF, symptoms at home	1 week
6	Enright P.L. *et al.* (1994)	Review article	—	—	—
7	Foo A.L. *et al.* (1996)	100	6–19	PEF, symptoms at home, FEV_1 at visit	2 weeks
8	Fritz G.K. *et al.* (1996)	5	10–15	PEF, FEV_1 symptoms at visit	1 day
9	Gern J.E. *et al.* (1994)	74	5–12	PEF, symptoms at home	6 months
10	Hewson P.H. *et al.* (1996)	27	10–15	19 patients: PEF, symptoms at home All: FEV_1	1 day
11	Linna O.V.E. (1991)	31	9–15 (mean 12.3)	PEF, symptoms at home	3 weeks
12	Linna O. (1996)	65	6–16 (mean 11.4)	PEF, symptoms at home	3 weeks
13	Molema J. *et al.* (1989)	14	16–37 (mean 27)	PEF, symptoms at home	6 weeks
14	Morris N.V. *et al.* (1996)	72	6–79	PEF at home Monash Respiratory Questionnaire	2 weeks
15	Pauli G. *et al.* (1995)	13	19–40	PEF, symptoms at home	16 weeks
16	Peiffer C. *et al.* (1992)	33	17–72 (mean 50)	PEF, symptoms at home	10 days
17	Quirk P.H. *et al.* (1990)	40	18–72 (mean 37)	FEV_1, 29 symptom questions	1 day
18	Reddel H.K. *et al.* (1995)	46	21–71 (mean 36.1)	PEF, symptoms at home	3 months
19	Santanello N.C. *et al.* (1997)	A: 239 B: 107	A: mean 35 18–65 B: mean 44	PEF, symptoms at home	A: 6 weeks B: 4 weeks
20	Teeter J.G. *et al.* (1998)	28	12–16 (mean 14)	PEF, symptoms at home	12 weeks
21	Uwyed K. *et al.* (1996)	67	mean 32.7	PEF, symptoms at home, FEV_1	7.9 weeks

primarily unexpected findings (e.g. normal lung function but many symptoms recorded). The authors concluded that a significant correlation between symptom score and PEF may be obtained if patients are given precise instructions about limiting the use of bronchodilator therapy.

In the fourth study (No. 18) published by Reddel *et al.* in 1995 (10), an index of PEF was compared with symptoms as well as with β_2-agonist use and PD_{20}. Forty-six adult patients at the clinic were asked to rate their symptoms using a frequency score from 0 to 4 (0 = no symptoms for 3 months, 4 = waking once or more a week because of asthma). The correlation between PEF and symptoms ($r = -0{\cdot}54$) was weaker than between PEF and PD20 ($r = -0{\cdot}21$), but both were statistically significant.

In the fifth study (No. 19) published in 1997 by Santanello *et al.*, two different scales for measuring asthma symptoms were compared with PEF (11). This is the only study that evaluates symptom scores with respect to asthma control. The daytime asthma symptom scale used a range of response categories for each question from 0 to 6, indicating the least to the most asthma symptomatology. The nocturnal diary scale used response categories ranging from 0 (indicating no awakenings with asthma symptoms) to 3 (indicating being awake all night due to asthma symptoms). Daily daytime scale scores were computed as the average of four questions: (a) frequency of general asthma symptoms; (b) inconvenience of asthma symptoms; (c) frequency of limitation during activities and (d) how often asthma symptoms limited ability to perform usual activities.

Weekly average scores for the nocturnal diary scale were computed in the same manner. The internal consistency, reliability, validity and responsiveness of both scales were assessed in 346 adult asthma patients in two placebo-controlled studies of an investigational asthma therapy, a leukotriene inhibitor.

TABLE 2. Symptoms and correlations *vs.* airway calibre

	Reference	Symptoms		Correlations Symptoms *vs.* airway calibre	Significance
		Score	Items		
1	Apter A.J. (1994)	1–4	cough, wheeze, chest tightness, dyspnoea	$r = -0{\cdot}59$–$0{\cdot}27$ (range all patients)	$P = 0{\cdot}0001$–$0{\cdot}12$ N.S. in 5/13 patients
2	Bailey W.C. (1992)	Yes–No slight-mod-severe 1–5	resp. symptoms bother scale	$r = -0{\cdot}21$ (resp. symptoms) $r = -0{\cdot}10$ (bother scale)	$P < 0{\cdot}01$ N.S.
3	Blanc P.D. *et al.* (1993)	0–28	history of hosp, frequency of symptoms, past and current use of steorids	$r = -0{\cdot}6$	$P < 0{\cdot}0001$
4	Boulet L.P. (1991)	0–10	dyspnoea, cough, chest tightness, phlegm	8 patients $r = 0{\cdot}685$–$0{\cdot}842$ 18 patients no correlations shown	$P < 0{\cdot}001$–$0{\cdot}004$
5	Carswell F. *et al.*(1990)	0–13	day, night	$r = -0{\cdot}20$ $r = -0{\cdot}33$	N.S. $P = 0{\cdot}05$
6	Enright P.L. *et al.* (1994)	review article	—	—	—
7	Foo A.L. *et al.* (1991)	0–4 0–2	night time symptoms morning tightness	$r = 0{\cdot}16$ (vs. FEV_1) $r = 0{\cdot}3$ (vs. PEF)	N.S. N.S.
8	Fritz G.K. *et al.* (1996)	VAS		$r = -0{\cdot}03$–$0{\cdot}50$	$P < 0{\cdot}05$ in 2/5 patients
9	Gern J.E. *et al.* (1994)	0–3	wheeze, cough activities	$r = 0{\cdot}22$	$P = 0{\cdot}058$
10	Hewson P.H. *et al.* (1996)	0–5	day, night	11 patients $r = 0{\cdot}3$ (vs. FEV_1)	CI: 0·16 to 0·47
11	Linna O.V.E. (1991)	0–3	day, night	$r = 0{\cdot}32$	N.S.
12	Linna O. (1996)	0–3	day, night	$r = -0{\cdot}25$	$P = 0{\cdot}06$
13	Molema J. *et al.* (1989)	0–3	dyspnoea, wheeze, cough	$r = 0{\cdot}27$ $r = 0{\cdot}14$	N.S. N.S.
14	Morris N.V. *et al.* (1996)	0–4 Yes–No	Monash Respiratory Questionnaire (14 questions)	$r = 0{\cdot}34$ (*vs.* PEF variability)	CI: 0·09–0·53
15	Pauli G. *et al.* (1995)	0–3	breathlessness, cough	$r = 0{\cdot}3905$	$P = 0{\cdot}001$
16	Peiffer C. *et al.* (1992)	VAS, 0–100 mm	dyspnoea	$r = 0{\cdot}04$ (carbachol group $n = 14$) $r = 0{\cdot}14$ (salbutamol group $n = 19$)	NS NS
17	Quirk P.H. *et al.* (1990)	VAS, 0–100 mm	29 symptom items	1 symptom item correlated with FEV_1	$P = 0{\cdot}01$
18	Reddel H.K. *et al.* (1995)	0–4, frequency	one symptom item	$r = -0{\cdot}54$	$P < 0{\cdot}0001$
19	Santanello N.C. *et al.* (1997)	0–6	daytime diary scale nocturnal diary scale	Day: A: $r = -0{\cdot}49$ Night: A: $r = -0{\cdot}32$ Day: B: $r = -0{\cdot}38$ Night: B: $r = -0{\cdot}51$	($-0{\cdot}58$ to $-0{\cdot}38$) ($-0{\cdot}53$ to $-0{\cdot}20$) ($-0{\cdot}43$ to $-0{\cdot}20$) ($-0{\cdot}64$ to $-0{\cdot}35$)
20	Teeter J.G. *et al.*	0–12	daytime cough or wheeze, notification of activities, nocturnal cough or wheeze	patient 1 $r = 0{\cdot}78$ patient 2 $r = 0{\cdot}02$	$P < 0{\cdot}0001$ $P = 0{\cdot}88$
21	Uwyed K. *et al.* (1996)	0–4	cough, dyspnoea, wheeze, notification of activities, nocturnal awakening	PEF: $r = 0{\cdot}384$ ($n = 58$) FEV_1: $r = 0{\cdot}143$ ($n = 70$)	$P = 0{\cdot}0029$ $P = 0{\cdot}263$

Statistical significance listed as *P*-values or CI. All data from publications.

The daytime symptom scale showed sufficient internal consistency (0.90–0.92), and the daytime and nocturnal symptom scales showed sufficient test–retest reliability (0.69–0.87). Construct validity was demonstrated by generally moderate to strong correlations between changes in the diary scales and changes in other measurements of asthma, such as FEV_1/PEF and number of rescue inhalations. Both scales also demonstrated significant responsiveness to change in asthma due to therapy in one of the clinical studies. The authors concluded that both the daytime and the nocturnal asthma symptom diary scales show measurement characteristics appropriate for use as asthma measures in clinical studies.

In addition, an asthma outcome study (No. 6) was published by Enright *et al*. in 1994 (12). This is a review article showing that all lung function tests were significantly correlated with each other and with symptom scores. However, no correlation tests were presented. Since there is no 'gold standard' with which to measure asthma severity, all of these tests contribute additional unique information when measuring asthma outcome.

Fifteen of the studies found low or no correlation between symptoms and airway calibre.

Study No. 1 (Tables 1 and 2) was published by Apter *et al*. in 1994 (13). Three clinical measures (symptom scores, morning PEF and number of rescue inhalations) were compared in 13 patients. It was concluded that the commonly used measures described above may not be interchangeable for describing the clinical course of asthma. It was also apparent that patients whose use of β_2-agonist is determined by symptoms tend to be more compliant.

In the study by Bailey *et al.,* published in 1992 (No. 2 in Tables 1 and 2), it was concluded that asthma severity appears to be multi-dimensional rather than uni-dimensional, and includes at least three components (14). They suggested the use of the 'Physician Rating Scale', as it provides a useful summary of the severity of the asthma. The three dimensions that were proposed were: (a) symptom intensity, (b) airflow impairment and (c) management intensity.

In the next study by Boulet *et al.,* published in 1991 (No. 4), recovery from asthma symptoms and lung function were compared in 26 patients after an acute exacerbation of asthma (15). Using a scale of 0–10 (0 = no symptom, 10 = maximum), the symptoms asked for were cough, dyspnoea, chest tightness and phlegm production. As expected, there was great variability in symptom scores. It was observed that patients with a shorter duration of asthma could not only perceive more symptoms, but could also discriminate their asthma symptoms better.

Number 5 (Tables 1 and 2) was published by Carswell *et al*. in 1990 (16). This is a study performed in 86 children with a mean age of 11·2 years in which the relationship between the physical severity of asthma and the family's knowledge and feelings about the disease was measured. The symptoms were recorded every day and were scored from 0–13 (maximum). The mean PEF recorded prospectively for 1 week correlated with the symptom score. Increased nocturnal symptoms correlated weakly with lower mean overnight PEF (not significant), and higher daily symptom scores correlated with lower mean daily PEF (statistically significant). It was concluded that more information is needed in order to increase families' knowledge of asthma.

In another study in children by Foo and Sly, published in 1991 (No. 7), no correlation was found between symptom scores (scored from 0–4, 0 = no symptoms) and FEV_1 or PEF (17). Their study showed that 35% of the children had abnormal lung function despite the fact that they had recorded very low symptom scores. The authors suggested that PEF-meters at home can provide a valuable aid for self-management.

In a study by Fritz *et al*. in 1996 (No. 8), symptom perception in childhood asthma was evaluated (18). These authors suggested an arithmetic calculation including a symptom scale (visual analogue scale, 0–100 mm), FEV_1 and PEF. They let the children guess their FEV_1 and their PEF and compared these values with the actual values. No correlation was shown as only five children participated, and they showed great variation. The authors suggested further research.

Gern *et al*. published a study (No. 9, 1994) of 74 children in which PEF variation and symptom scores were compared (19). The symptom scores included wheezing or coughing and daily activities, and were scored from 0–3 (0 = none or no limitation, 3 = persistent symptoms or daily routine modified). The change in symptom scores did not follow the change in diurnal variation of PEF, and no correlation was found between them. The usefulness of the diurnal variation was discussed, and the conclusion was that it is an imprecise indicator of the severity of asthma.

The next study, by Hewson *et al*. (No. 10, 1996), compared lung function tests and asthma symptoms in 27 adolescents (20). Asthma symptoms were scored from 0–5 for daytime and night-time as follows: 0 = no symptoms during the previous 2 weeks, 5 = symptoms so severe as to affect normal activities or sleep. Most of the patients with low PEF values of 25–75% predicted who did not correlate with symptoms had values below 55% of predicted value. The conclusion was that measurement of lung function should be part of the clinical assessment.

The following two studies were published by Linna, in 1993 (No. 11) and in 1996 (No. 12) (21,22). Both studies were performed in children, and the conclusion was that symptom scores in a diary are a poor basis for the assessment of childhood asthma. The value of monitoring PEF at home was discussed, and it was concluded that this is of limited value when assessing the degree of severity of asthma.

In a study by Molema *et al*., published in 1989 (No. 13), asthma symptoms were obtained and compared with other objective measures such as FEV_1, β_2-agonist use and PC_{20} (23). The symptoms asked for were daytime dyspnoea, wheeze and cough, as well as nocturnal dyspnoea and wheeze, and the scores were from 0–3 (0 = no symptoms, 3 = severe symptoms). Fourteen adult patients with exercise-induced asthma participated. No correlation was found between the symptom scores and any of the other measurements. The conclusion was that symptom scores are of little value in assessing the severity of the disease.

In a study by Peiffer *et al*. from 1992 (No. 16), the relationship between spontaneous dyspnoea and the lability of airway obstruction in asthma was investigated (24). The correlation coefficient *r* between dyspnoea scores (VAS scores, 0–100 mm) and PEF (*r* DSc-PEF) was determined. There was a large inter-subject difference in the characteristics of dyspnoea.

In the study by Quirk and Jones, published in 1990 (No. 17), a visual analogue scale was used (25). Twenty-nine items referred to severity and frequency of symptoms such as frequency of cough, wheeze, shortness of breath and sputum production. There was no significant association in a regression of FEV_1 against the mean score for each of the 40 patients. It appeared that symptoms alone contributed relatively little directly to the overall level of the disease experienced by patients.

Another study showing no correlation between lung function and symptoms was published by Teeter and Bleeker in 1997 (No. 20) (26). In that study six symptoms, including cough, dyspnoea, wheeze, chest tightness, sputum production and nocturnal awakenings, were rated by 67 patients on a scale from 0 (none) to 4 (constant). Asthma symptoms did not correlate with FEV_1 or PEF. The authors noted that following treatment, subjective improvement in asthma symptoms could occur without any improvement in measurements of airway obstruction.

In the last study by Uwyyed *et al*. from 1996 (No. 21), children completed a diary including the following symptoms: nocturnal cough or wheeze, daytime cough or wheeze, and limitation of normal activities, with a maximum possible daily score of 12 (27). Low correlations were found between the daily symptom scores and the lung function measurements. There was a higher correlation between PEF and symptoms in children with more severe disease.

Taken together these studies demonstrate that there are only weak correlations between objective measures of airway calibre, such as FEV_1/PEF, and subjective measures such as symptoms.

SYMPTOM SCALES

Great variation was found in the scales/scoring systems used in the studies reported here. Scores of 0–3, where 0 means no symptoms and 3 means maximum symptoms, were used in four studies. In some studies the symptoms were divided into cough, breathlessness and wheeze, whereas in other studies daytime and night-time symptoms were recorded. In a few studies both combinations were used. Scales using ratings of 0–4, 0–5, 0–10 and 0–12 were also used, and with great variation. In three of the studies a visual analogue scale was used. As mentioned previously, no two studies used the same scale, which is a drawback since no comparisons can be made between the results.

The study by Santanello *et al*. demonstrated an attempt to standardize the scale by comparing different items and analysing them by using a psychometric test. It must be mentioned, however, that this scale is not a severity scale but an asthma control scale. This is the only study in the review that presented an asthma control scale; all other publications included different questions or scales concerning symptom severity. One of these is the severity module in the Monash Respiratory Questionnaire, which seems well validated and constitutes a good attempt to standardize the measurement of the severity of asthma.

Discussion

It is obvious from this review that objective measurements such as FEV_1/PEF and subjective asthma symptom scales give different information about the status of a patient's asthma. Many of the authors concluded that it is of importance to measure FEV_1/PEF in order to control the severity of asthma, especially in children who may not be aware of any deterioration in their asthma. However, it seems reasonable that objective measurements as well as the subjective ones are important to have the full picture of a patient and his/her disease. It may be discussed if a patient should measure PEF or fill in a symptom questionnaire every morning. In clinical studies it is often the case but not in real life. When looking at the correlations between PEF and symptoms, these were not higher when comparing FEV_1 with symptoms (Table 2). It must be highlighted that the variety of studies in terms of design, patient number and study duration is an advantage in drawing any conclusions. Data on confidence intervals are not presented in the majority of studies which also adds weaknesses to the review.

In mild asthma with almost no decrease in FEV_1 or PEF, there is a need for a sensitive subjective measurement of the symptoms that exist in this patient group. When comparing different treatments in clinical studies, there is a need for a standardized asthma control scale. The scale presented by Santanello *et al*. constitutes a good attempt to standardize a scale. A similar asthma control scale was recently developed by Juniper *et al*. (28). This questionnaire was tested in a 9-week observation study of 50 patients with asthma. The reliability of the questionnaire was high (ICC = 0·90) and the responsiveness to change was significant ($P < 0{\cdot}0001$). However, further evaluation of the questionnaire is required, as the number of patients was relatively small and the group may have been homogenous.

To summarize, 21 studies were identified in which correlations were sought between objective measures such as FEV_1/PEF and subjective measures such as asthma symptoms. The majority of the studies found no significant correlation. Great variation exists in the way asthma symptoms are evaluated, with each study employing a different set of symptoms and scales. A few attempts have been made to standardize the recording of symptoms, but at present no asthma symptom scale can be considered ideal or reliable. Further work is needed, especially in the development of scales applicable to patients with very mild asthma in whom lung function measurements are typically normal. It is also important to highlight the linguistic validation of symptom scales. The recommendations given for quality of life questionnaires can be used as guidelines for symptom scales with some modifications. The conclusion is that for the time being, objective measurements still

provide the best information about the severity of a patient's asthma status.

Further research is needed for: (a) development of standardized and validated symptom scoring systems; (b) development of validated symptom scores/scales for mild asthma; (c) exploration of the relationship between symptom perception and compliance with therapy; and (d) understanding the physiological basis of asthma symptoms.

References

1. Juniper EF, Kline PA, Vanzieleghem MA, Ramsdale EH, O'Byrne PM, Hargreave FE. Effect of long-term treatment with an inhaled corticosteroid (budesonide) on airways hyperresponsiveness and clinical asthma in nonsteroid-dependent asthmatics. *Am Rev Respir Dis* 1990; **142:** 832–836.
2. Nguyen B-P, Wilson SR, German DF. Patient's perceptions compared with objective ratings of asthma severity. *Ann Allergy Asthma Immunol* 1996; **77:** 209–215.
3. Cockroft DW, Swystun VA. Asthma control versus asthma severity. *J Allergy Clin Immunol* 1996; **98:** 1016–1018.
4. Van der Molen T, Postma DS, Schreurs AJM, Bosveld HEP, Sears MR, Meyboom de Jong B. Discriminative aspects of two generic and two disease-specific instruments: relation with symptoms, bronchodilator use and lung function in patients with mild asthma. *Quality of Life Research* 1997; **6:** 353–361.
5. Weiss KB. The health economics of treating mild asthma. *Eur Respir Rev* 1996; **6:** 33, 45–49.
6. Jones PW. Quality of Life, health economics and asthma. *Eur Respir Rev* 1995; **5:** 279–283.
7. Blanc PD, Jones M, Besson C, Katz P, Yelin E. Work disability among adults with asthma. *Chest* 1993; **104:** 1371–1377.
8. Morris NV, Abrahamson MJ, Rosier MJ, Strasser RP. Assessment of the severity of asthma in a family practice. *J Asthma* 1996; **33:** 425–439.
9. Pauli G, Bigot H, Pelletier A, Kopferschmitt-Kubler MC, Roegel E. A study of the criteria for clinical evaluation of prophylactic treatment in bronchial asthma. *Eur Respir J* 1985; **67:** 369–377.
10. Reddel HK, Salome CM, Peat JK, Woolcock AJ. Which index of peak expiratory flow is most useful in the management of stable asthma? *Am J Respir Crit Care Med* 1995; **151:** 1320–1325.
11. Santanello NC, Barber BL, Reiss TF, Friedman BS, Juniper EF, Zhang J. Measurement characteristics of two asthma symptom diary scales for use in clinical trials. *Eur Respir J* 1997; **10:** 646–651.
12. Enright PL, Lebowitz MD, Cockroft DW. Psychologic measures: pulmonary function tests. Asthma outcome. *Am J Respir Crit Care Med* 1994; **149:** 9–18.
13. Apter AJ, ZuWallack RL, Clive J. Common measures of asthma severity lack association for describing its clinical course. *J Allergy Clin Immunol* 1994; **94:** 732–737.
14. Bailey WC, Higgins DM, Richards BM, Richards JM Jr. Asthma severity:a factor analytic investigation. *Am J Med* 1992; **93:** 263–269.
15. Boulet LP, Milot J, Turcotte H. Relationship between changes in diurnal variation of expiratory flows, lung volumes and respiratory symptoms after acute asthma. *Respir Med* 1991; **85:** 487–493.
16. Carswell F, Heck G, Robinson E, Hallows D, Peters T, Stanton T. Family stress and childhood asthma. *Nurs Pract* 1990; **3:** 10–15.
17. Foo AL, Sly PD. Pulmonary function in a hospital population of asthmatic children. *J Asthma* 1991; **28:** 273–280.
18. Fritz GK, Yeung A, Wamboldt MZ, Spirito A, McQuaid EL, Klein R, Seifer R. Conceptual and methodological issues in quantifying perceptual accuracy in childhood asthma. *J Pediatric Psychol* 1996; **21:** 153–173.
19. Gern JE, Eggleston PA, Schuberth KC, Eney ND, Goldstein EO, Weiss ME, Adkinson NF Jr. Peak flow variation in childhood asthma: a three-year analysis. *J Allergy Clin Immunol* 1994; **93:** 706–716.
20. Hewson PH, Tippett EA, Jones DM, Maddern JP, Higgs P. Routine pulmonary function tests in young adolescents with asthma in general practice. *Med J Aust* 1996; **165:** 469–472.
21. Linna OVE. Twice daily peak expiratory flow rate monitoring for the assessment of childhood asthma. *Allergy Proc* 1993; **14:** 33–36.
22. Linna O. Spirometry, bronchodilator test or symptom scoring for the assessment of childhood asthma. *Acta Paediatr* 1996; **85:** 564–569.
23. Molema J, van Herwaarden CL, Folgering HT. Effects of inhaled budesonide on the relationships between symptoms, lung function indices and airway hyperresponsiveness in patients with allergic asthma. *Pulm Pharmacol* 1989; **1:** 179–185.
24. Peiffer C, Toumi M, Razzouk H, Marsac J, Lockhart A. Relationship between spontaneous dyspnoea and lability of airway obstruction in asthma. *Clin Science* 1992; **82:** 717–724.
25. Quirk FH, Jones PW. Patient's perception of distress due to symptoms and effects of asthma on daily living and an investigation of possible influential factors. *Clin Science* 1990; **79:** 17–21.
26. Teeter JG, Bleecker ER. Relationship between airway obstruction and respiratory symptoms in adult asthmatics. *Chest* 1998; **113:** 272–277.
27. Uwyyed K, Springer C, Avital A, Bar-Yishay E, Godfrey S. Home recording of PEF in young asthmatics: does it contribute to management? *Eur Respir J* 1996; **9:** 872–879.
28. Juniper EF, O'Byrne PM, Guyatt GH, Ferrie PJ, King DR. Development and validation of a questionnaire to measure asthma control. *Eur Respir J* 1999; **14:** 902–907.